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RESEARCH ARTICLE

SEDIMENTOLOGICAL STUDIES ON THE (KAHYLIA & OKHEIDER MOUNTAINS), MIDDLE EOCENE LIMESTONES, NORTHWEST GULF OF SUEZ, EGYPT

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Abstract

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The Middle Eocene limestone succession (of Lutetian age) exposed at the area extends along the Western side of Gulf of Suez to the south western scarp of Gabel Ataqa, including Gabel Kahylia to the north and Gabel Okheider to the south, is differentiated from base to top into: Minia Formation and Mokattam Formation.

The detailed petrographic analyses of 107 samples taken from two measured, stratigraphic sections in the study area, have led to the recognition of six main types of limestone depositional facies they are: Packstone - to gainstone (30%), grainstone (28%), packstone (22.4%), wackestone- to packstone (15%), wackestone (2.8%) and lime -mud to wackestone (1.8%).

Field observations, beside microfacies investigation, helped in reaching that the Minia Formation and the overlying Mokattam Formation have been deposited on an isolated shallow marine platform (carbonate bank), reflecting sedimentary environments of Nummulites bank facies, carbonate bar facies and restricted lagoon facies.

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INTRODUCTION

The study area forms part of the great Eocene plateau of the Northern Eastern Desert of Egypt. It consists of series of elongated and widely- spaced North-West and East-West trending topographic highs and lows, which are mainly structurally controlled. It extends along the Western side of Gulf of Suez between Latitudes $29^{\circ} 40^{\circ}$ and $30^{\circ} 00^{\circ}$ N, and Longitude $32^{\circ} 00^{\circ}$ and $32^{\circ} 30^{\circ}$ E, covering an area about 800 sq km. (Fig1). It occupies the area between the south western scarp of Gabel Ataqa to the northeast, including Gabel Kahylia to the north and Gabel Okheider to the south.

The Lithostratigraphy of the Eocene exposures in the north Eastern Desert has been a subject of study for many authors. The most important are those carried out by Blancknhorn (1900), Cuvillier (1941), Al-Ahwani (1982), Strougo (1985 a,b), Strougo and Boukary (1987), Abd-Elshafy et al. (1989), Strougo and Abd-Allah (1990), Strougo et al. (1992); Abu El-Enain and Ismail (1995), Bignot and Strougo (1994 & 2002). However, there is not overall accepted classification regarding the Eocene stratigraphic subdivision, and different terms had been given in various parts of the north Eastern Desert. Both pre-rift and syn-rift sedimentary successions are represented in the study area. The exposed pre-rift sediments are represented by the Tertiary rock units of Middle and Late Eocene exposures. The syn-rift sediments are represented by the Neogene rock units belonging to Oligocene and Miocene exposures. (Fig.2). The Oligocene exposures are represented by continental sands, quartizite and gravel sediments of



Gabal El-Ahmer Formation, which caped the Eocene rocks at both northwestern and southeastern parts of the study area (Fig.2)

Fig.(1): Location map of the study area

2. EXPERMENTAL PROCEDURES

Two major stratigraphic sections are measured to clarify the facies characteristics of the studied sequence. The first section is sampled at the eastern scarp of Gabel Kahylia along the western bank of wadi Haugl (Figs 3). The second section is samples at Gabel Okheider along Cairo-Sukhna road (Fig 4). About 107 microscopic thin sections representing the studied Middle Eocene sequence are described and an adequate photographical classifications is given using Dunham classification (1962), which is modified by Embery and Klovan's (1971). It is distinguished two major formations in the studied carbonate section. The first one is the Minia Formation is recorded only at Gabel Okheider section (Fig2), where it measures about 70m thick. It shows unconformable relationship with the overlying Mokattam Formation H.S. Hassan (2013). The other section is the Mokattam Formation is widely distributed along both sides of the Cairo-Sukhna road (Fig 2). The Mokattam Formation which, is recorded in both Gabel Okheider section is overlying unconformably the Minia Formation with a thickness reaches 65m, and Gabel Kahylia section where it attains about 120m thickness (Fig 2) H.S. Hassan (2013).

Careful analysis of the studied microfacies leads to the delineation of six main types of limestone depositional textural facies comprising 16 microfacies types. They are: Packstone – to gainstone (30%), grainstone (28%), packstone (22.4%), wackestone- to packstone (15%), wackestone (2.8%) and lime –mud to wackestone (1.8%) (Figs 3&4).

The following is a brief description of the identified limestone facies and microfacies types, showing their vertical and lateral distribution in the studied sequences.

<u>1. Packstone – to Grainstone Facies.</u>

The packstone – to grainstone facies have an effective role in the building the greatest part of the studied Middle Eocene sequence including both the Minia and the Mokattam formations. They are recorded in all the studied sections at Okheider (8.4%) and Kahylia (11.2%).

Petrographically, the packstone/grainstone facies consists of different varities of biofounal elements depending on the depositional environments. They include foraminifera, nummulites, pelioides, molluscas, interaclasts and unknown bioclasts. Consequently, this texture can be subdivided into four main microfacies as follows:

1.1 Foraminiferal nummulitic packstone/grainstone microfacies.

This microfacies are represented mainly in the outcrop by thinly bedded, bioclastic, fossiliferous white limestone. It represents the most dominant types in the Mokattam Formation at Kahylia section about (7.5%), especially in its lower parts. At Okheider section it reaches about (0.93%) in the Mokattam Formation and about (2.8%) in the Minia Formation especially near its top parts. (Plate.1 Fig (A&B).

1.2. Echinodermal bioclastic packstone / grainstone microfacies.

The rocks of this microfacies occupy the middle part of the Mokattam Formation at Kahylia section (about 8%), reaching about 8m. thick. It is recorded also at Okheider section (about 20%), represented in both the Minia and Mokattam formations, in the lower, middle and upper parts reaching a thickness of 17m. exhibit bioturbation. (Plate.1 Figs. C, D, G&H).

1.3. Peloidal packstone / grainstone microfacies.

This microfacies is recorded only in the Mokattam Formation at Kahylia section (about 5%), reaching about 4 meters in the thickness. In the outcrop it represented by yellowish grey, thickly bedded limestone. (Plate.1. Figs E&F).

2 Grainstone Facies

Gainstone facies have an effective role in building the greatest part of the Minia Formation (8.4%), and the Mokattam Formation (7.5%), at Okheider section. Also they are well developed in the upper part of the Mokattam Formation at Kahylia section. (11.2%). Generally, the grainstone textures in the studied area are characterized by the following microfacies:

2.1. Foraminiferal bioclastic grainstone microfacies.

This microfacies is represented in the outcrop by thick to thinly bedded, biogenic limestone exhibit bioturbation. It constitutes (7.5%), Mokattam Formation at Kahylia section reaching up to 25 meter thick. Also it is well developed at Okheider section attaining 16 meter thick in both the Minia (3.7%) and Mokattam (2.8%), formations. (Plate.2. Fig A&B).

2.2. Echinodermal bioclastic grainstone microfacies.

This microfacies occurs at the middle part of the Mokattam Formation at Kahylia section (3.7%) reaching about 8 meters thick. At Okheider section it occurs at numerous horizons in the Minia Formation (4.7%), attaining about 10 meters thick, and occupies the upper most part of the Mokattam Formation (2.8%), reaching about 6 meter thick. (Plate.2. Fig C&D).

2.3. Nummulitic bioclastic grainstone microfacies.

This micofacies is recorded only in the lower part of the Mokattam Formation at Okheider section (1.8%), attaining about 4 meters thick. In the outcrop it is characterized by highly bioturbated, white, fossiliferous thinly bedded limestone. (Plate.2. Figs E&F).

3. Packstone Facies

The packstone facies are well represented in the Minia Formation (9.4%), and the Mokattam Formation (5.6%), at the Okheider section, as well as the Mokattam Formation at Kahylia section (7.5%), forming bed, which repeated vertically several times. Generally, it includes the following varieties:

3.1. Echinodermal bioclastic packstone microfacies.

This microfacies is widely distributed in all studied sections. It represented in the middle part of the Mokattam Formation at Kahylia section (3.7%), attaining about 4.6 meters thick. While at Okheider section, it is recorded in both the lower part of the Minia Formation (8.4%), reaching about 12 meter thick and the Mokattam Formation (4.6%), reaching about 6 meter thick. (Plate.3 Fig A&B).

3.2. Foraminiferal packstone microfacies.

This microfacies is less abundant in the studied sections. It is recorded only in the Mokattam Formation at Kahylia section (1.9%) attaining about 5 meters thick. While at Okheider it is recorded only in the lower part of the Minia Formation (0.9%), reaching about 3 meters thick. (Plate.3 Fig. E,F&G).

3.3. Molluscan bioclastic packstone microfacies.

This microfacies is developed only in the Mokattam Formation at the lower part of the Kahylia section (2.8%), reaching about 4 meters thick and the top part at Okheider section (0.9%), and reaching 1.5 meters thick. (Plate.3 Fig. C&D).

4. Wackestone - to Packstone Facies

The wackestone/packstone facies are less pronounced in the studied sections. They are represented by about 6 meters thick in the lower parts of the Mokattam Formation at Kahylia section (6.5%). At Okheider section these textures are recorded in both the Minia Formation (3.7%), reaching about 6 meters thick and the Mokattam Formation (4.7%), attaining about 4.6 meters thick. Generally, these textures are represented by the following microfacies.

4.1. Echinodermal bioclastic wackestone- to packstone microfacies.

This microfacies is recorded in the lower part of the Mokattam Formation at Kahylia section (2.8%), reaching about 2 meters thick. It is also, developed at Okheider section in both the Minia Formation (3.7%), attaining 6 meters thick, and the Mokattam Formation (3.7%), reaching 3 meters thick. On the outcrop, it occurs as thinly bedded bioturbated limestone. (Plate.4. Fig C&D).

4.2. Nummulitic bioclastic wackestone- to packstone microfacies.

This microfacies occurs only at the base of Mokattam Formation at Kahylia section (1.9%), reaching about 2.5 meters thick. In the Outcrop, it exposes as yellowish white, massive, bioturbated limestone. (Plate 4. Fig. A&B)

4.3. Molluscan wackestone- to packstone microfacies.

This mircofacies occurs only in the Mokattam Formation in the studied section. At the Kahylia section it developed near the base (0.9%), reaching 1.5 meters thick, whereas in the Okheider it occurs near the top (1.8%), attaining 6 meters thick. (Plate 4. Fig E,F,G&H).

5. Wackestone Facies

The wackestone facies are the less prominent depositional textures in the studied sequences. These facies textures are encountered only in the lower part of the Mokattam Formation at Kahylia section, as well as, in the upper part of the Minia Formation at Okheider section. They are subdivided into the following microfacies:

5.1. Echinodermal wackestone microfacies.

This microfacies encountered only in the upper part of the Minia Formation at Okheider section (1.9%), reaching to 4 meters thick. It exposes in the field as bioturbated white limestone exhibit cross-laminiation. (Plate.5. Fig. B).

5.2. Molluscan wackestone microfacies.

This microfacies is developed only in the lower part of the Mokattam Formation at Kahylia section (0.9%), reaching 3.5m thick. In the outcrop, it is yellowish white bioturbated limestone. (Plate.5. Fig. A).

6. Lime- mud- to Wackstone Facies.

These facies are less abundant in the studied sequence. They are represented in the Mokattam Formation at both Kahylia and Okheider sections. They are represented by the following microfacies types:

6.1. Echinodermal lime- mud - to wackstone microfacies.

This microfacies is recorded only in the lower part of the Mokattam Formation at Kahylia section (0.9%), reaching about 3 meters thick. The rocks is grayish white, thick-bedded limestone and slightly to moderately bioturbated. (Plate.6. Fig. A).

6.2. Molluscan lime- mud - to wackstone microfacies.

This microfacies is detected only at the top of the Mokattam Formation at Okheider section (0.9%), attaining 2.5 meters thick. It is represented by yellowish white, thinly bedded limestone. (Plate 6. Fig. B).

4. RESULTS AND DISCUSSION.

Form the detailed sedimentological investigation, About 107 microscopic thin sections representing the studied Middle Eocene sequence are described using Dunham classification (1962), which is modified by Embery and Klovan's (1971). The detailed stratigraphic sedimentological investigation studies to the carbonate sections lead to six main types of limestone depositional facies comprising of 16 microfacies types. The main six recognized facies are: Packstone - to gainstone (30%), grainstone (28%), packstone (22.4%), wackestone - to packstone (15%), wackestone (2.8%) and lime -mud to wackestone (1.8%). According to, the field observation of the studied carbonate rock facies and to the diversity ratio of all allochemical components existing in each facies: The sedimentary environments are comprised of: Nummulites bank facies, carbonate bar facies and restricted lagoon facies are proposed for the studied Middle Eocene sequence (Figs 6&7). Moreover, the studied Middle Eocene of the Minia Formation and the overlying Mokattam Formation have been deposited on an isolated shallow marine platform (carbonate bank), with high carbonate productivity.



Fig.(2): Geological map of the study area showing the studied sections (After CONOCO, 1989)



Fig (3). Shows the vertical distribution of the main microfacies types and associations at Kahylia section.

			Depositional Texture (Dunham, 1962)						Carbonate				
Stage	Rock units	Samples No	М	w	Р	G		Microfacies	м	w	Ρ	G	
Middle Eocene	Mokattam Formation	66 - 65 - 64 - 65 - 64 - 65 - 64 - 66 - 65 - 64 - 66 - 66						Echinodermal Bioclastic Grainstone Moullsca Bioclastic Packstone Foraminifera Bioclastic grainstone Echinodermal Pack to grainstone Moullscan Lime mud to Wakestone Echinodermal Bioclastic Packstone Echinodermal Bioclastic Wacke to Packstone					
		49 48 47 46 45 44 43 42 41 40 39 38 37						grainstone Echinodermal Bioclastic Packstone Foraminiferal Pack to grainstone Molluscan Grainstone Foramifral Grainstone Echinodermal Packstone Foramifral Bioclastic Grainstone Nummulitic Bioclastic Grainstone Echinodermal Packstone Echinodermal Bioclastic Pack to grainstone					
		36 35 33 33 32 32				* = * *	8 X	Echinodermal Packstone Echinodermal Wacke to Packstone Echinodermal Wackstone Echinodermal Wacke to Packstone		-			_
	Minia Formation	31 30 					★ @ * Q	Echinodermal Bioclastic grainstone					
		28 27- 26- 25-						Muoliscan Packstone Foraminifral Bioclastic Pack to grainstone Foraminiferal Bioclastic Grainstone					
		24 23 22 21 21 28					- anne ≈anne : aù	Echinodermal Bioclastic Pack to grainstone					
		18-		Η			\$100 W W	Echinodermal grainstone			_		
		17-				会談]an ==	Echinodermal Packstone	<u> </u>		_		-
		16 — 15 —						Foraminitral Bioclastic Grainstone	-				$\left - \right $
	4	14					**	Echinodermal grainstone			-		
	o meters	13				*=0	•	Echinodermal Bioclastic Packstone					
		11]☆⊲⊠	Echinodermal grainstone			-		
		19 }				*=	,	Echinodermal Bioclastic Packstone					
		6 = 5 - 4 - 3 - 2 -				# ⊡ * ≹⊛		Echinodermal Bioclastic wacke to Packstone			_1		

Fig. (4). Shows vertical distribution of the main microfacies types and associations at Okheider section.



Fig.(5): Legend of symbols used in the present study.



<u>Plate 1</u>

Scale:- C.N, X50

R Е

Plate 2

Scale:- C.N, X50

<u>Plate 3</u>



Scale:- C.N, X25



Plate 4

Scale:- C.N, X50

<u>Plate 5</u>



Scale:- C.N, X25

<u>Plate 6</u>



Scale:- C.N, X50



Fig. (6): Imaginary lateral and vertical distribution of the main sedimentary facies (environments) in the studied area (not to scale).



(KH) Kahylia section



Fig. (7): Depostional model showing the shallow marine carbonate bank and associated facies that developed during the Middle Eocene in the studied area. (OK) Okeider section.

(KH) Kahylia section

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